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FINAL REPORT

AIR POLLUTION EMISSIONS ASSOCIATED WITH NONSYNTHETIC HYDROCARBON APPLICATIONS FOR PESTICIDAL PURPOSES IN CALIFORNIA

VOLUME I - EXECUTIVE SUMMARY

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ABSTRACT

This report presents the results of analysis of the use pattern of 1977 estimated nonsynthetic hydrocarbons used for pesticidal purposes in California. Alternative measures and their associated impacts that can lead to a use reduction of the nonsynthetics are also presented. The entire analysis in this report is based on estimated oil use obtained by questionnaire surveys and 1977 California Pesticide Use Report.

The total estimated consumption of nonsynthetic hydrocarbons for pesticidal purpose in 1977 in California was 225.2 million pounds. Of this quantity, 96.5% was applied in pure oil form (formulation 10), and 3.5% as minor ingredients (nonformulation 10). The formulation 10 products were applied in four categories: general weed control (53.9%), agricultural use (27.5%), wood preservation (11.8%), and miscellaneous uses (3.3%). The general weed control use overlaps with the second and fourth categories. The miscellaneous uses of oil pesticides include home and garden, industrial, manufacturing, residential pest control, etc.

The top 17 commodities that had 500,000 pounds or more of oil pesticide applied were studied with regard to oil use pattern, related pest problems and alternative measures capable of reducing oil use. The total possible quantity of oil that could be saved and the associated hydrocarbon emission reduction are estimated. Recommendations are made on the most feasible alternative measures for reducing oil use based on energy, economic and air quality impact assessments.

Each of the alternative measures are evaluated for their impacts on air quality, energy use, health and cost. All alternatives can achieve a reduction of hydrocarbon emissions as shown below.

Alternatives	Estimated Oil Use Reduction (in 1000 lbs.)	Potential Emission Reduction tons/TPD[a]	Potential % Reduction in Total Oil Use
Synthetic Pesticides			
Insecticide	11,063.4	4,949/13.6	5.1
Herbicide	111,127.0	52,630/144.2	51.1
Application Method	4,023.2-5,275.7	1,813-2,202/5.0-6.0	1.9-2.4
IPM (Integrated Pest Management)	4,573.9-9,147.6	2,047-4,096/5.6-11.2	2.1-4.2

[a]TPD = Tons per day.

The alternatives will also result in reduced energy consumption. The estimated annual energy use reductions were from 55,307 barrels of crude oil equivalent for alternative application methods, 63,793-143,399 barrels for IPM practices and 1,875,370 barrels for synthetic pesticide. The energy consumption resulting from conventional oil application was 1,899,365 barrels of crude oil equivalent.

Cost analysis of different alternatives provided a somewhat different impact pattern. The costs of synthetic pesticides and their application are higher for citrus and low for deciduous tree crops when compared to the costs of oil insecticide use. In vegetable crops the cost of synthetic herbicidal treatment is about three times lower than the cost for control with weed oil. For school district and weed control unclassified, the synthetic herbicidal treatment cost is higher than for oil use. Costs for IPM-synthetic practice are higher and equivalent for IPM-oil practice when compared to non-IPM oil use for the three citrus crops. These costs, however, are the cost for treatment year. With IPM, treatment may not be required for each year. For the long term consideration, the cost for IPM will be reduced and become very competitive with conventional oil application. The use of low volume spray can result in oil use reduction and thus in cost savings.

Based on the impacts assessment of the different alternatives summarized earlier, the following conclusions are made with consideration given to hydrocarbon emission reduction, cost and energy use in descending priority of importance.

(1) Synthetic insecticides and herbicides are available as substitutes for all but three of the crops considered in this report. These materials are, in general, more toxic than the oil pesticides. Investigations of the relative health impacts are beyond the scope of this study. The cost of synthetic herbicides, on the other hand, varies depending on the particular applications, but in general are comparable to the costs of nonsynthetics.

(2) Oil use reduction can be achieved in part by increasing the use of low volume and new sprayer

techniques for some of the oil application on deciduous and citrus tree crops.

(3) IPM procedures may or may not result in immediate oil use and cost reductions. In the long term consideration, oil use and cost reduction can be achieved.

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1.0 CONCLUSIONS

The following conclusions are based on the interpretation of data presented in this report.

(1) The total estimated consumption of oil pesticide in 1977 in California was 225.2 million pounds. Of this quantity, 217.3 million pounds (96.5%) was applied in pure oil form (formulation 10), and 7.9 million pounds (3.5%) as minor ingredients (non-formulation 10). The formulation 10 products were applied in four categories: general weed control (53.9%), agricultural use (27.5%), wood preservation (11.8%), and miscellaneous uses (3.3%). The total organic gas (TOG) emissions from formulation 10 oil pesticide use was 91,010 tons or 249.3 tons per day (TPD) and about 41 percent of this emission took place in June through October. When compared to CARB's 1976 Statewide Emission Inventory, the 1977 oil pesticide emissions would account for 10.3 percent of the TOG emissions from all stationary sources. In some counties, however, this source of emissions accounts for more than half of all stationary source emissions. (e.g. San Joaquin County - 55%: Monterey County - 64%).

The major emission peaks during the year were in April through June and then maintained at a relatively high monthly emission rate through September. The months of relatively high emissions correspond best to both the high ambient levels of TOG in some areas in the state and a high frequency of oxidant standard violations. It appears that pesticide oil applications during the summer and fall months could contribute significantly to oxidant problems in some areas.

(2) A reduction in the use of pesticide oil with a resultant emission reduction can be achieved by synthetic pesticide substitution, using more efficient application methods and by adopting IPM practices. The emission reduction achievable by synthetic pesticide substitution was 157.8 TPD or 63.3 percent of the annual total oil use, and the reduction achievable by new application methods and IPM procedures was 5.0-6.0 TPD (1.9-2.4 percent of the total emission from oil use) and 5.6-11.2 TPD (2.1-4.2 percent of the total emission from oil use) respectively.

(3) Alternative measures examined would result in a reduction in energy use. The reduction was 55,307 barrels of crude oil equivalent for using more efficient application methods, 63,793-143,399 barrels for IPM practices, and 1,875,370 barrels for synthetic pesticides. The energy consumption of conventional oil application was equivalent to 1,899,365 barrels of crude oil equivalent.

(4) In comparing the cost of alternatives with conventional oil applications, the cost of materials and application labor in using synthetic insecticides and most herbicides were generally lower. With IPM practices, during the treatment year, costs on a per acre basis are higher than costs for non-IPM oil use. Since a high level of treatment is not required each year with IPM, costs for IPM practice could be lower in the long run. Considerable saving would result in changing to more efficient application methods. The average costs per acre and the relative cost effectiveness of emission reduction on a per ton basis realized in each of the alternatives for those commodities considered in this study, are presented below. Relative cost effectiveness is defined in this report as cost above or below the cost of oil use.

Alternative	Potential Emission Reduction tons/TPD[a]	Average Relative Cost Effectiveness ($/ton of Emission Reduced)[b]
Synthetic Pesticides		
Insecticides	4,949/13.6	-1,054
Herbicides	52,630/144.2	143
IPM (Integrated Pest Management)		
Oil	2,047/5.6	673
Synthetic	4,096/11.2	1,032
Application Methods	1,813-2,202/5.0-6.0	-568

[a]TPD - Tons per day.

[b] - sign denotes a savings.

(6) Based on the possible impact that each alternative may have on public health, energy use, costs and air quality, the following alternatives are recommended for consideration of implementation in order to reduce oil use.

- Use of more efficient application methods
- Adoption of IPM procedures
- Synthetic herbicide substitution

2.0 RECOMMENDATIONS

(1) Three alternative measures are recommended for implementation to the extent possible for the reduction of hydrocarbon emission from oil pesticide use. These alternatives are synthetic herbicide substitution, adoption of IPM procedures and use of more efficient application methods.

The use of weed oil for non-crop areas and for those field crops considered in this report could be phased out with synthetic herbicide substitutions. There is some question, however, on the availability of a real substitute for stoddard solvent as herbicide for carrots. With the current increases in price of petroleum products and energy considerations, the use of weed oil may be gradually phased out voluntarily by the end-users themselves.

IPM procedures are available for tree fruits which include grapefruits, lemons, oranges, and pears.

Reduction in oil use and costs could be achieved by using low volume spray and tower sprayers.

(2) Implementation of the recommended alternatives can be accomplished either by voluntary program or enforcement procedures. Economic feasibility should be one of the prime considerations in taking any implementation steps.

(3) IPM procedure development is an existing function of the University of California and the California Department of Food and Agriculture (CDFA). With the current interest of the Air Resources Board on air pollution emissions from pesticide use, research fundings should be pooled and efforts coordinated between relevant institutions and agencies.

(4) Air pollution emissions may not be a current primary concern of the regulatory function of the CDFA, and if this is the case, the air pollution concern should be integrated into the overall pest management consideration.

(5) The current emission inventory was based primarily on survey sales and use data. A study of this design has some limitations with regard to assuring the accuracy and representativeness of data. Data generated by this approach should be validated by source reconciliation field studies. Validation should include intensive survey of end-users in the studied areas. Such an effort is especially important in better defining the pesticide uses in what are now included in the category of weed control unclassified.

3.0 EXECUTIVE SUMMARY

3.1 Introduction

The primary objective of this project is to identify the use patterns of nonsynthetic hydrocarbon (NSHC) pesticides in California and recommend possible alternative substitutes for the NSHC pesticides. In achieving this objective, a 1977 application and emission inventory associated with the pesticidal usages of NSHCs in California was conducted. Specifically, this project seeks to:

1. Identify the use patterns of NSHCs in pesticidal applications including applications for agricultural, home and garden, and other non-agricultural uses,
2. Recommend possible alternative pest control methods as substitutes for NSHC applications with the primary purpose of reducing NSHC uses,
3. Inventory the hydrocarbon emissions associated with NSHC applications as herbicides and insecticides, and
4. Establish a general methodology(ies) for an emission inventory of NSHCs used for pesticidal purposes.

This entire report consists of three volumes. The body of the report is presented in Volume II, while the executive summary and appendices are presented in Volumes I and III respectively.

The body of the report in Volume II is presented in four parts. The first part is primarily concerned with data collection, application inventory and concomitantly delineating the use patterns of NSHC pesticides. The second part is to present the emission inventory. The third part is to identify possible alternative methods which may lead to a reduction in NSHC applications. The last part provides an environmental, economic, and energy impact assessment of the alternative pest control methods.

3.2 Application and Use Pattern Inventories

The total estimated consumption of nonsynthetic hydrocarbons for pesticidal purpose in 1977 in California was 225.2 million pounds. Of this quantity, 96.5% was applied in pure oil form (formulation 10), and 3.5% as minor ingredients (non-formulation 10). The formulation 10 products were applied in four categories: general weed control (55.7%), agricultural use (28.4%), wood preservation (12.2%) and miscellaneous uses (3.7%). The last three categories involve application of oil pesticides to specific uses, while information for the first category is insufficient for specific use designation. The general weed control use overlaps with the second and fourth categories. The miscellaneous uses of oil pesticides include home and garden, industrial, manufacturing, residential pest control, etc.

The use patterns of pesticide oils in California in 1977 are reflected in the temporal and spatial distribution of the pesticide oils. The majority of the oil was applied during the spring and summer months, and most of the oils applied at this time were herbicides. The counties in which most of the pesticide oil was applied are located in non-attainment areas for ozone. In addition, most of these counties are located in air basins which have the state's most serious ambient ozone problems. Studying use patterns of pure oil pesticides is important for air quality planners attempting to determine the significant sources of air quality problems and the most effective means of reducing emissions. Not only does total pesticide oil use vary widely among the 58 counties and throughout the year, but major commodities and pesticide oil types also vary significantly. Air quality planning must take this latter fact into account in forming control strategies.

The data reported in this application inventory were based in part on a number of estimates and assumptions, as discussed in Section 5.0 of Volume II. These estimates were derived in two steps. The initial step was to arrive at a statewide total oil pesticide consumption. The second step was to make a detailed breakdown of oil pesticide application by county and by use.

The 1977 statewide oil pesticide consumption estimate was 225.2 million pounds. The oil pesticides include 177.7 million pounds of formulation 10 products, 26.6 million pounds of creosote, 13.1 million pounds of miscellaneous oil (e.g. diesel oil, road oil, etc.) and 7.8 million pounds of non-formulation 10 oil. The formulation 10 figure of 177.7 million pounds was extrapolated from the dealers' survey responses. This figure is considered to be conservative when it is compared to the reported sale of 141.4 million pounds by 45% of the oil pesticide manufacturers in California. Further credence is lent to this figure since it was extrapolated from 282 dealers' responses, a rather significant statistic. The data on creosote applications are well supported numbers. The creosote data were derived from wood preservers' inputs and calculations based on the number of cross ties to be treated in the total railroad track mileage in every county in California. The data on non-formulation 10 oil and miscellaneous oil applications represent the best available data to date. The non-formulation 10 data were obtained from the 1977 PUR,[3] which excluded the improper, unrecorded and unreported pesticide applications. The non-formulation 10 oil pesticides are usually applied as a minor ingredient in synthetic products. There is no information available as to the quantity of unreported synthetic pesticide applied in California. The miscellaneous oil use was extrapolated from a low farmer survey response (8%). It is felt that data reported here for non-formulation 10 and miscellaneous oil uses are conservative estimates. The estimate for these two categories is less than 10 percent of the total applied oil pesticide.

The task of breaking down application estimates by county and by use was more difficult than estimating total quantities. The distribution of oil pesticide use was based primarily on the 1977 PUR with specific information from county farm advisors for specific crops in individual counties. Some of the distributions in smaller use categories may deviate considerably from actual use but quantities involved have less influence on the total distribution.

Patterns based on surveys were used for oil used in wood preservation, school districts and vector control. The first two include data from a significant number of respondents and the last includes data for all of the oil applied by vector control agencies. The data are probably the most accurate among all categories.

There are some uncertainties about the specific uses of general weed oil. The use pattern estimates reported here are based on the grower survey response, the school district and vector control surveys and the sale of weed oil products registered for various uses as reported by dealers. None of these give an accurate picture of use for all of the weed oil applied, but the estimates represent the best obtainable from the available data.

In summary, the data reported are reasonable. This study relied upon several assumptions, and, at the same time, it represents a major effort in developing an inventory of pesticide use where applications are mostly unreported. More importantly, it's findings include a large quantity of pesticides which have never been reported previously.

Several areas that deserve further consideration are recommended. First, the use of pesticides in home and garden applications should be investigated more thoroughly. Although the relative amount of oil pesticide use in this sector is rather small, the quantity of synthetic pesticide use may be significant.

Secondly, effort should be extended toward defining the unreported synthetic pesticide use. At present, there is no requirement for farmers or non-commercial applicators to report the use of unrestricted synthetic pesticide applications. Such information is important for hydrocarbon emission inventory especially for those counties classified as nonattainment areas for ozone.

For use in estimating hydrocarbon emissions from pesticides, manufacturers of pesticide oils should be required to report to state agencies on an annual basis the quantity of various types of oil sold by them in California. An alternative approach is to require the manufacturer to submit annual sales records by pesticide formulation type to the state. This information can be pooled together as a statewide statistics, and thus avoid revealing confidential sales information.

3.3 Emission Inventory

A methodology for estimating emissions from applied NSHC pesticides was developed. This method depends primarily on a model developed by Hartley (1969) for pesticide volatilization from surface deposits. The basic equation for emission rate estimation is derived from physical principles. After the initial rate is established, the emission rate is considered to follow a time-course through each month which is first order or a summation of two first order time courses.

The factors considered in the methodology include:

- Emission during pesticide application;
- Sorption and sequestering application;
- Degradation of pesticide;
- Emission from surfaces of soil, vegetated land and water;
- Time-dependent change in emission rate.

Depending on the weather variables during applications and emissions, emission rates calculated with this methodology range from 85 percent to 95 percent of the applied pesticides.

The emission methodology developed in this study is the most comprehensive effort attempted for estimating hydrocarbon emissions resulting from pesticide applications.

Attempts were made to include most of the recent published experimental data in the model. There still remain, however, areas in need of additional experimental data to validate and strengthen the model. These areas may include particularly estimation of emission during application, time-dependent changes in emission rate and pesticide degradation.

The 1977 statewide emissions due to formulation 10 NSHC pesticide applications amount to 182 million pounds of TOG or 249 TPD. Compared to the CARB's 1976 Emission Inventory data, these TOG emissions represent 10.7 percent of TOG emissions from all stationary sources in California. The emissions from formulation 10 NSHC pesticide applications varies in individual counties, however. Expressed as a percentage of TOG emissions from all stationary sources, the TOG emissions resulting from NSHC pesticide applications ranged from 64 percent in Monterey County to 5.5 percent in Kern County. It is evident that emissions from NSHC pesticide use in some counties have become a major stationary source of emissions which may have significant impacts on the air quality.

The emission sources of NSHC pesticides come from primarily two usages: agricultural use and general weed control. Data on agricultural use were derived from well supported survey data. The general weed control use data were derived from a limited number of survey responses. The emission data resulting from NSHC pesticide use for general weed control represents the best available data to date.

Based on the findings in this study, there are several areas that deserve attention and/or further consideration of research effort. First, some of the parameters (e.g. emission during application, pesticide degradation and soil adsorption) considered in the emission estimation methodology are based on limited available published data. As experimental data becomes available in the future, the methodology should be reviewed and revised.

Secondly, the current emission inventory was based primarily on survey sales and use data. A study of this kind definitely has some advantage in that a large quantity of data can be obtained in a relatively short time in order to generate an approximate estimate. This type of study, however, has some limitations with regard to assuring the accuracy and representativeness of data. Data generated by this approach should be validated by source reconciliation field studies by monitoring and measuring chemically the pollutants which are unique to different emission sources. Validation should include intensive survey of end-users in the studies areas. Such an effort is especially important in better defining the pesticide uses in what are now included in the category of weed control unclassified.

Finally, if emission data presented in this study are to be used to formulate air quality attainment strategies, attention should be directed towards data for specific areas, and control strategies should be based upon the oil pesticide use patterns and the hydrocarbon emission loads during the smog season in each area.

3.4 Alternatives

Applications of petroleum oil pesticides in California can be significantly reduced by the substitution of alternative pest control methods. The estimated pounds and percentage reduction in oil use which could be obtained by substitution of 4 alternative methods is shown in Table 3-1 for 14 crops and 4 nonacreage applications.

Synthetic Pesticides. The use of synthetic pesticides is by far the most effective of the presently available substitutes for oil. Table 3-1 indicates this alternative would have significant effectiveness for oil in 14 of the high oil usage categories and could reduce oil applications by up to 122 million pounds. Synthetic chemicals would not be an effective substitute for all of the oil use without a serious loss of effectiveness. Synthetics are useful only as a partial substitute for oil in some crops because (1) only some pests of a crop can be controlled with synthetics, (2) the synthetics are effective in only some parts of the state or (3) substitution of synthetics is acceptable only part of the time, e.g. when weather conditions are favorable.

As an alternative to the use of petroleum oil pesticides in California, the use of synthetic pesticides should

TABLE 3-1

Estimated Potential Reduction in F-10 Oil Use by Alternative Control Methods

Crop or Other Application	Oil Use[a] (in 1000 lbs.)	Synthetic Pesticides		Application Methods		Integrated Pest Management (IPM)		Mechanical & Cultural Control	
		Oil Use Reduction		Oil Use Reduction		Oil Use Reduction		Oil Use Reduction	
		(%)	(weight in 1000 lbs.)	(%)	(weight in 1000 lbs.)	(%)	(weight in 1000 lbs.)	(%)	(weight in 1000 lbs.)
Insecticide									
Grapefruit	499.0	100	499	LV 15 Spr 10	74.9 49.9	45-90	225- 449.1	0	0
Lemon	6,122	100	6,122	LV 10 Spr 13	612.1 795.7	45-90	2,754.9- 5,509.8	0	0
Orange	3,543	100	3,543	LV 15 Spr 10	531.4 354.3	45-90	1,594.3- 3,188.4	0	0
Almond	8,157	< 1	0	LV 10-15	815.7- 1,223.6	N/A	0	0	0
Apricot	635	< 1	0	LV 10-15	63.5- 95.3	N/A	0	0	0
Nectarine	736	< 1	0	LV 10-15	73.6- 110.4	N/A	0	0	0
Peach	2,576	3	77.3	LV 10-15	257.6- 386.4	N/A	0	0	0
Pear	2,293	20-30	458.6- 687.9	LV 10-15	229.3- 343.9	Negligible	0	0	0
Plum	714	2	14.3	LV 10-15	71.4- 107.1	N/A	0	0	0
Prune	938	20-30	187.6- 281.4	LV 10-15	93.8- 140.7	N/A	0	0	0
Vector Control	4,433	0	0	0	0	N/A	0	0	0
Herbicide									
Alfalfa	12,473	50	6,236.5	0	0	N/A	0	0	0
Alfalfa (Desiccant)	4,570	100	4,570	0	0	N/A	0	0	0
Avocado	1,240.2	100	1,240.2	0	0	N/A	0	0	0
Carrot	11,099	48	5,327.5	0	0	N/A	0	50[imp]	5,550
Citrus	3,650	100	3,650.0	0	0	N/A	0	0	0
Weed Oil Unclassified	117,812	75	88,359	0	0	N/A	0	10	11,781
School District	3,502	50	1,751	0	0	N/A	0	0	0
Other									
Wood Preservative	26,550	0	0	0	0	N/A	0	0	0
TOTAL:			122,036- 122,359		4,023.2- 4,825.7		4,574.2- 9,147.3		11,781

a - Application under Home & Garden excluded.

LV - Low volume spray application.

Spr - Improved coverage sprayer application method.

N/A - No available method.

imp - Considered impractical due to excessive labor and cost.

be considered technically the most complete and satisfactory substitute.

Application Methods. The use of alternative application methods could lead to a considerable reduction in applied pesticide oil. Alternative application methods could be used for application to the crops in Table 3-1 to give reductions of 10 to 25 percent in oil use for each crop. The application methods which can be used are the use of low volume sprays and the use of tower sprayers for improved spray distribution on citrus. Both of these methods are now used to some extent on those tree crops where they are applicable. There could be excessive cost involved with a short-term conversion to these methods.

The use of low volume spray methods for fruit trees and improved coverage sprayers for citrus crops should be promoted and encouraged as a means of reducing the use of petroleum oil pesticides.

Integrated Pest Management. Tested IPM methods could be used on citrus in those areas of the state where most pesticide oil is applied. This use of IPM could lead to reduction in oil applications on citrus crops of 40 to 90 percent depending upon whether low volume use of oil or synthetic chemicals were used in the program for mite control.

IPM could not bring reductions in oil use on most crops because they do not have developed and tested IPM programs. In the IPM program for pears, oil use is part of the established method, and it cannot be substituted with other chemicals.

IPM methods of control are not readily implemented since trained supervisors are needed for its use. Additionally, there is a lack of trained IPM supervisors, and growers are reluctant to use their services.

The use of integrated pest management (IPM) methods should be promoted and encouraged as a means of reducing pesticide oil use in citrus crops. Research should be encouraged for the development of IPM methods for other crops which can reduce the use of petroleum oil pesticides.

Mechanical and Cultural Control. Application of mechemical and cultural control methods can have only a very limited effect on pesticide oil usage. In tree crops there are no direct mechanical or cultural methods against insects and mites. Mechanical or hand cultivation can be used to remove weeds from row crops but is considered prohibitively expensive.

Research towards the development and testing of mechanical and cultural methods capable of reducing petroleum oil pesticide use should be promoted and encouraged.

3.5 Impacts Assessment

Based on evidence presented in this study, there are technically feasible alternatives available to either partially or completely substitute for pesticidal oil use. Synthetic pesticides are available for all commodities considered in this report with the exception of almonds, apricots and nectarines. Oil use reduction can be achieved by using low volume and new sprayer techniques in some applications of all citrus and deciduous tree crops. IPM procedures have been developed for grapefruits, lemons, oranges and pears.

These alternatives were evaluated in some detail for their impacts on energy consumption, costs and air quality, and these impacts are summarized qualitatively in Table 3-2. All alternatives resulted in reduced hydrocarbon emissions. Table 3-2 presents a summary of comparative impacts among the alternative pest control methods discussed in this study. In arriving at these comparative impacts, impacts of oil pesticide on energy consumption, economics and air quality were used as reference points. Impacts of other alternative methods which are either above or below those of oil pesticides are judged as having increased or decreased impacts. A detailed explanation of this comparative impact rating system is presented as footnotes in Table 3-2.

The potential annual emission reduction ranged from a low of 4 million pounds by switching to more efficient application methods to a high of 122 million pounds for synthetic pesticide substitution. A similar trend of reduction in energy consumption among the alternatives was also observed.

The results of the cost analysis of different alternatives provided a somewhat different impact pattern. The costs of synthetic pesticides and their application on citrus were higher than for oil use and were lower on deciduous tree crops.

TABLE 3-2

A Summary of Comparative Impact Formulation of Alternative Pest Control Methods for 16 Commodities

Crop	Energy Impact[a]				Economic Impact[b]				Air Quality Impact[c]			
	Oil	Synthetic[d]	Application[e]	IPM[d]	Oil	Synthetic[d]	Application[e]	IPM[d]	Oil	Synthetic[d]	Application[e]	IPM[d]
Grapefruit	0	-	-	-	0	+	-	+	0	-	-	-
Lemon	0	-	-	-	0	+	-	+	0	-	-	-
Orange	0	-	-	-	0	+	-	+	0	-	-	-
Almond	0	NA	-	NA	0	NA	-	NA	0	NA	-	NA
Apricot	0	NA	-	NA	0	NA	-	NA	0	NA	-	NA
Nectarine	0	NA	-	NA	0	NA	-	NA	0	NA	-	NA
Peaches	0	-	-	NA	0	-	-	NA	0	-	-	NA
Plum	0	-	-	NA	0	--	-	NA	0	-	-	NA
Prunes	0	-	-	NA	0	--	-	NA	0	-	-	NA
Pears	0	-	-	0	0	-	-	++	0	-	-	0
Alfalfa	0	-	NA	NA	0	--	NA	NA	0	-	NA	NA
Avocado	0	-	NA	NA	0	-	NA	NA	0	-	NA	NA
Carrot	0	-	NA	NA	0	--	NA	NA	0	-	NA	NA
Citrus	0	-	NA	NA	0	-	NA	NA	0	-	NA	NA
School District	0	-	NA	NA	0	+	NA	NA	0	-	NA	NA
Weed Control Unclassified	0	-	NA	NA	0	+	NA	NA	0	-	NA	NA

[a]Energy Impact
- 0 = energy use by oil pesticides and serves as reference point of comparison with other alternatives.
- \- = decrease or saving in energy use as compared to oil pesticides.
- \+ = increase in energy use as compared to oil pesticides.

[b]Economic Impact
- 0 = cost of using oil pesticides ($/acre), and serves as reference point of comparision with other alternatives.
- \- = decrease in cost ($/acre) by 1X as compared to oil pesticides.
- -- = decrease in cost ($/acre) by 2X or more as compared to oil pesticides.
- \+ = increase in cost ($/acre) by 1X as compared to oil pesticides.
- ++ = increase in cost ($/acre) by 2X or more as compared to oil pesticides.

[c]Air Quality Impact
- 0 = hydrocarbon emission of oil pesticide and serves as reference point of comparison with other alternatives; it also represents hydrocarbon emissions of other alternatives similar to oil use.
- \- = decrease in hydrocarbon emission as compared to oil pesticide.
- \+ = increase in hydrocarbon emission as compared to oil pesticide.

[d]NA = not available
[e]NA = not applicable

In vegetable crops the cost of synthetic herbicidal treatment was about three times lower than the cost for control with weed oil. For herbicidal purposes for school districts and weed control unclassified, however, the cost was higher when synthetic pesticides were used. Costs for IPM-synthetic and IPM-oil practices were both higher than non-IPM oil use for the three citrus crops. These costs, however, were the cost for the treatment year. With IPM, treatment may not be required each year. For the long term consideration, the cost for IPM will be reduced and become very competitive with conventional oil application.

Based on the impact assessments of the different alternatives summarized earlier, the following conclusions are made with consideration given to hydrocarbon emission reduction, cost and energy use in descending order of priority.

(1) Synthetic insecticides and herbicides are available as substitutes for some of all of the oil use for all but three of the crops considered in this report. The synthetic insecticide use has been shown to be <u>more costly</u> with some crops and with greater health impact to the public than oil use. The synthetic herbicides, on the other hand, have slight health impacts to the public equivalent to that of weed oil but with <u>lower</u> costs.

(2) Oil use reduction can be achieved in part by increasing the use of low volume and new sprayer techniques for some of the oil application on

deciduous and citrus tree crops.

(3) IPM procedures may or may not result in immediate oil use and cost reduction. However, in the long term consideration, oil use and cost reduction can be achieved.

Based on data presented and discussion made in Chapter 7 and 8 of Volume II on the technical feasibility and various possible impacts of different alternatives, three recommendations are made as options for implementation to reduce hydrocarbon emissions resulting from oil pesticide use.

Use of More Efficient Application Methods. The "application methods" alternative, although the least effective alternative in terms of reducing hydrocarbon emissions from pure oil application, is by far the most cost effective approach. By switching to more efficient, lower volume and air tower sprayer application methods, the pesticide user saves a significant amount of money. These savings alone should serve as an incentive to implement this alternative, and compliance with this approach could be entirely voluntary. If necessary, however, enforcement procedures could be developed.

Implementation of a voluntary program would require a user education program. Such a program could be carried out by either the county agricultural commissioners office (possibly with state funding or assistance) or at the state level by the Department of Food and Agriculture and/or the

U.C. Extension Service. Implementation of an enforced system would be more complex. All nonsynthetics could be added to the list of restricted pesticides thereby placing stringent controls over the labeling of such substances and the manner in which they could be applied. Such an action would require action by the CDFA and quite probably a change in existing law governing the classification of pesticides. Actual enforcement would be left up to the county agricultural commissioners.

Other approaches to modifying application methods for pure oils could conceivably include the "burn day" concept currently applied to agricultural burning, or regulating the time of day at which oils could be applied. The burn day concept would theoretically restrict pure oil applications to the days on which meteorological conditions favor rapid dilution and dispersal of organic gases, preventing significant build-up of ozone in the ambient air. The time of day approach would theoretically reduce the impact of hydrocarbon emissions by insuring that the pure oil pesticides would be applied at a time, such as late afternoon or early evening, when solar insolation would be insufficient to result in ozone formation. Both the burn day and time of day approaches would fail to be completely effective, however, because the evaporation of pure oils is slow enough that the resulting hydrocarbon emissions will carry over into the next day or even much longer. In addition, meteorological conditions would often likely be detrimental to effective spraying late in the day or on "no-burn" days. Additionally, it is generally of critical importance to apply pesticides within a narrowly defined time period. By forcing the pesticide user to wait several days or even weeks, as in the "burn day" approach, irreversible crop damage may be suffered.

Synthetic Pesticide Substitution. The substitution of synthetic herbicides for nonsynthetics, is clearly the most effective alternative for reducing hydrocarbon emissions.

The implementation of the synthetic substitution alternative could be achieved by actions similar to those described previously for the application methods alternative. Implementation could be on either a voluntary or on an enforcement basis. Through the education efforts outlined earlier, pesticide users could be encouraged to shift from nonsynthetics to synthetics in those cases where synthetics would cost the same or less and would have equivalent toxicity ratings. For those crops and applications where synthetics are more expensive and are relatively low in health impact, some added incentive to use synthetics could possibly be provided by government refunds of the mill tax (originally charge to the manufacturer of synthetics) directly to the user who substitutes synthetics for nonsynthetics during the summer and fall smog season in certain areas. This latter governmental incentive (or any other similar incentive involving payments or tax credits) would require changes in existing tax laws.

Implementation of the synthetic substitution alternative by enforcement may involve the classification of nonsynthetics as restricted pesticides as discussed previously.

Development of IPM Procedures. IPM is probably the best long term alternative. IPM involves a complex interaction of pest control methods, biological controls, crop management practices and other techniques. Under the IPM procedures, pesticides are applied on a need basis only. To fully implement IPM will take years of research and extensive education of growers and others who currently use pesticides. Additional trained personnel will be needed to implement the IPM program. Although existing agricultural agencies in California (CDFA, county agricultural commissioners, etc.) will have most of the responsibility for implementing IPM, additional help is needed to speed up the establishment of IPM as a routine practice. Air pollution regulatory agencies, including the CARB, could be an important influence in establishing IPM through funding research and education programs and/or influencing public policy decisions on IPM implementation by stressing air quality benefits.

In summary, a more effective approach to reduce hydrocarbon emissions from oil pesticide applications involves the use of all three alternatives. The end-users of oil pesticides should be educated to use the more efficient application methods. Synthetic herbicides with low toxicity and costs and existing available IPM recommendation of combining different alternatives for oil use reduction is a reasonable approach from the standpoint of cost effectiveness, health and air quality impact.